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Linda Partridge
PROTON ENERGY SYSTEMS
50 Inwood Road
Rocky Hill, CT 06067

Re: New United States Patent Application
For: POWER BRIDGING APPARATUS FOR BACKUP POWER SYSTEMS
Your Reference: PES-D-01008
Our Reference: PES-0086

Dear Linda:

Enclosed for your review and comments is the first draft of an application which has been prepared for the above-referenced matter. Please review the draft carefully, especially for technical accuracy, mark any changes directly on the draft and return to me at your earliest convenience.

In the meantime, you should also be aware that applicants for a patent are required to disclose all known, material information to the Patent and Trademark Office. Information includes but is not limited to publications, technical literature and foreign and U.S. patents, including any related foreign and U.S. applications or patents. Information is defined as "material" if there is a substantial likelihood that a reasonable examiner would consider it important in deciding whether to allow that application to issue as a patent. Information is not material if it is merely background, cumulative to other disclosed information, or unpublished research. The failure to disclose material information can result in the issued patent (and any related patent) being found invalid and/or unenforceable.

Please have the inventor(s) forward to us copies of any articles or other information which they consider material to the above application as soon as possible. If they later become aware of any other prior art which might be material to patentability of the subject invention they must also bring it to our attention as soon as possible.

I would also appreciate you providing us with the inventors' full names, residence addresses, post office mailing addresses, counties in which they reside, and citizenships on the enclosed sheet and returning it to us so that we may prepare the formal papers. Please advise us if there is any question as to inventorship. Otherwise, we will assume that the named inventors on the attached sheet are correct.

If you have any questions regarding this matter, please do not hesitate to contact me.

With best regards,

Very truly yours,

Leah M. Reimer

Leah M. Reimer, Ph.D.

LMR:dkm
Enclosures

PROTON ENERGY SYSTEMS

PATENT DOCKET LETTER

DATE: _____

Docket No.: PES-D-01 008

The invention disclosed herein is submitted with the request that a docket be opened and a docket number assigned.

BRIEF DESCRIPTIVE TITLE OF INVENTION:

Fuel Cell Backup Power Bridge Device Utilizing High Voltage Capacitor Energy Storage

PRIOR ART: (Related patents, dockets, reports, articles, texts, etc.)

none known

SUMMARY: (State problem to be solved and concisely summarize the essential, novel solution)

See attached. This invention allows a backup power system, based on a fuel cell, to provide a temporary power "bridge" during the transition from normal power operation to backup power operation using a high voltage capacitor power source. This provides a simple replacement for a battery, super capacitor, or a flywheel bridge system. The novel solution is to use a high voltage (approx 500 VDC) low quality power supply to charge a medium size capacitor (10,000 uF (micro-Farads)) as an energy storage device and then discharge this into the existing high quality power supply system using another low quality / low cost regulator interface. The result is large energy storage with minimal component increase relative to other energy storage solutions.

DOCUMENTATION:

Date Conceived: _____

First Sketch or Description of Concept (Notebook #, Drawing #, etc.): PES042 page 13-15

Disclosed Outside of Proton Energy Systems, Inc.? YES ☐ NO ☑

READ AND UNDERSTOOD:

Witness: _____ **Date:** _____ **Inventor:** _____

Witness: _____ **Date:** _____ **Inventor:** _____

PROTON ENERGY SYSTEMS

PROTON INVENTION DISCLOSURE QUESTIONNAIRE

Attach this questionnaire to the front of the invention disclosure when disclosing inventions and new ideas to Proton.

TITLE OF INVENTION:	
Fuel Cell Backup Power Bridge Device Utilizing High Voltage Capacitor Energy Storage	
DISCLOSURE NUMBER: PES-D-01 008	**LEGAL REFERENCE NUMBER:**

1. SPECIFIC DEVELOPMENT OF THIS INVENTION:

a) Date invention was conceived. _____

b) Has the invention been successfully built or tested? YES ☐ NO ☑

IF YES, WHEN? AND HOW:

IF NO, WHAT FUTURE EFFORT IS PLANNED TO BUILD OR TEST THIS INVENTION?

Proton will probably work with a third party to test this design or it will be tested internally at Proton.

c) Current or potential uses/products:

Main use will be in backup power systems especially 24 and -48 VDC systems, although there is applicability for all backup systems.

d) Was this invention conceived under a government contract? YES ☐ NO ☑

Contract Number: _____

2. DISCLOSURE OF INVENTION OUTSIDE PROTON:

a) Has the invention been disclosed to others outside Proton, or included in any printed publications, seminars, presentations, trade shows, exhibits? YES ☑ NO ☐

IF YES, DISCLOSED TO WHOM AND UNDER WHAT CIRCUMSTANCES?

No details were disclosed but prior to fully developing this invention I questioned a vendor (Semikron at PES, conf room A, Tom O'Reilly, Andy Camardo) to see if they had a system that could act as a bridge but

b) Date of Disclosure: _____

c) Was a Non-Disclosure Agreement in place? YES ☐ NO ☑

3. DOES THIS INVENTION RELATE TO ANY OTHER INVENTION DISCLOSURES?

YES ☐ NO ☑ **If yes, which disclosures?** _____

Inventor(s) Signature	Full Name	Proton Emp.	Phone #	Social Security No.
	Mark Lillis	yes	860 571-6533 x-236	021-46-2213

Title: Fuel Cell Bridge Capacitor System

Problem: Regenerative fuel cell systems may need time to get running, but users want uninterrupted power. Solutions can be things like adding a battery as a "bridge" power source. However, having a battery in the system means that we still have battery maintenance problems. Other schemes such as flywheels and so called "super-cap" can be used but at high costs.

Solution: Normal capacitors run at higher voltages can store much more energy than using larger caps with "normal" voltages. This is because cap energy is based on the square of the applied voltage. Additionally, the higher charge voltage allows more discharge before the voltage drops below an un-usable level for the DC→DC supply that would be used to convert the cap energy into a controlled & usable voltage/current.

Higher voltage can easily be obtained with a lower performance charging power supply (DC-DC) since charge rate is not an important factor.

The cap can be discharged thru the existing DC/DC power supply that is part of a fuel cell system or a seperate DC-DC power supply can be used. The cap discharge can be actuated by various methods including a FET/transistor from a voltage or a current sense that indicates an interrupt of the grid voltage.

Continued on Page 14

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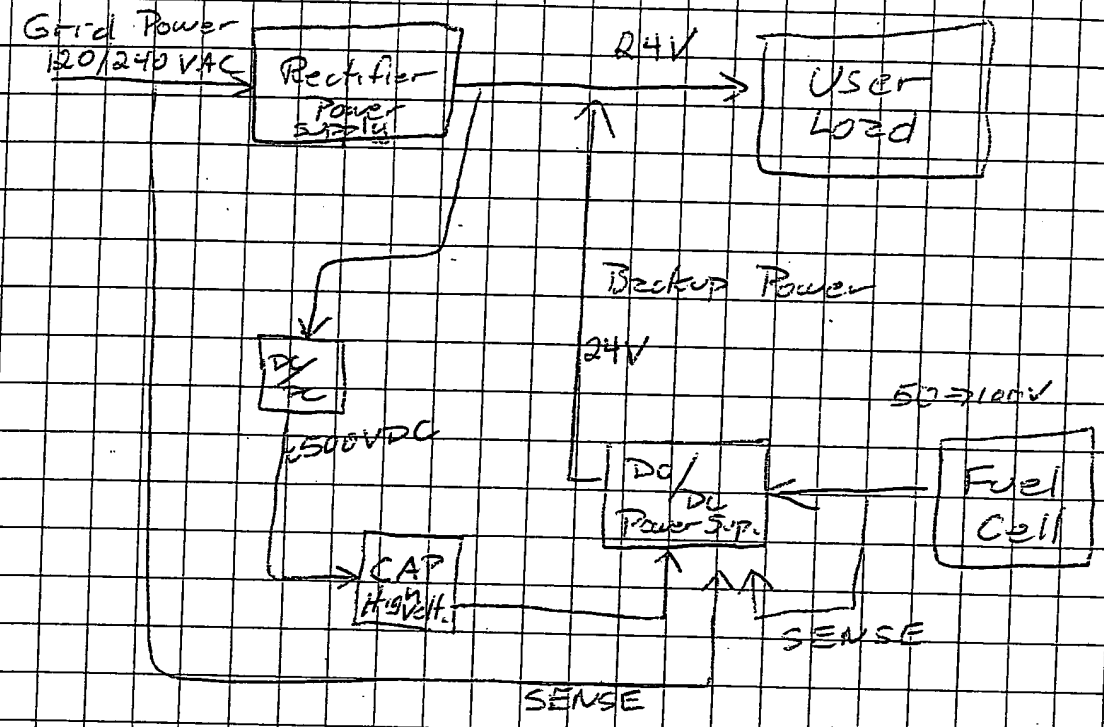
Signed Date Signed Date

Typical Block Diagram



Typical Cap may be Mallory CGS772T450X8L
7700uF 450VDC / 525 Surge

Cap discharge energy is added into switcher DC/DC supply via a regulator, possibly into input stage or at the switcher's existing cap stage. The High Voltage cap system is shutoff once the Fuel Cell begins full power generation. By using the existing DC/DC supply as an entry point for this bridge power, the DC/DC supply can 'soft switch' between the High Power cap and the fuel cell as the cell comes on-line. Sensings of load switching ~~may be~~ and power control may be part of the power supply but can also be part of another control system system.

Continued on Page 15

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Signed / Date

PROJECT Backup Power (FC Bridge) Notebook No. PES042

Continued From Page 14

The following table shows the relationship of cap voltage vs. energy storage. Caps of 7700 and 10,000 uF were used. 10kW power output was used.

GIVEN		RESULTING VALUES				
cap size	cap voltage	resulting cap	resulting charge	resulting energy	energy	energy
F	V	uF	C	J	Ws	kWs
Farads	Volts	micro-Farads	Coulombs	Joules	Watt-seconds	kWatt-seconds
0.0077	25	7700	0.19	60	60	0
0.0077	50	7700	0.39	481	481	0
0.0077	75	7700	0.58	1624	1624	2
0.0077	100	7700	0.77	3850	3850	4
0.0077	125	7700	0.96	7520	7520	8
0.0077	150	7700	1.16	12994	12994	13
0.0077	175	7700	1.35	20634	20634	21
0.0077	200	7700	1.54	30800	30800	31
0.0077	225	7700	1.73	43854	43854	44
0.0077	250	7700	1.93	60156	60156	60
0.0077	275	7700	2.12	80068	80068	80
0.0077	300	7700	2.31	103950	103950	104
0.0077	325	7700	2.50	132163	132163	132
0.0077	350	7700	2.70	165069	165069	165
0.0077	375	7700	2.89	203027	203027	203
0.0077	400	7700	3.08	246400	246400	246
0.0077	425	7700	3.27	295548	295548	296
0.0077	450	7700	3.47	350831	350831	351
0.0077	475	7700	3.66	412612	412612	413
0.0077	500	7700	3.85	481250	481250	481
0.0077	525	7700	4.04	557107	557107	557
0.0077	550	7700	4.24	640544	640544	641
0.0077	575	7700	4.43	731921	731921	732
0.0077	600	7700	4.62	831600	831600	832
0.0077	625	7700	4.81	939941	939941	940

GIVEN	RESULTING VALUE	
Output Power	Resulting Holdup Time	
kW	s	min
kilo-Watts	seconds	minutes
10	0.01	0.0
10	0.05	0.0
10	0.16	0.0
10	0.39	0.0
10	0.75	0.0
10	1.30	0.0
10	2.06	0.0
10	3.08	0.1
10	4.39	0.1
10	6.02	0.1
10	8.01	0.1
10	10.40	0.2
10	13.22	0.2
10	16.51	0.3
10	20.30	0.3
10	24.64	0.4
10	29.55	0.5
10	35.08	0.6
10	41.26	0.7
10	48.13	0.8
10	55.71	0.9
10	64.05	1.1
10	73.19	1.2
10	83.16	1.4
10	93.99	1.6

GIVEN		RESULTING VALUES				
cap size	cap voltage	resulting cap	resulting charge	resulting energy	energy	energy
F	V	uF	C	J	Ws	kWs
Farads	Volts	micro-Farads	Coulombs	Joules	Watt-seconds	kWatt-seconds
0.001	25	1000	0.03	8	8	0
0.001	50	1000	0.05	63	63	0
0.001	75	1000	0.08	211	211	0
0.001	100	1000	0.10	500	500	1
0.001	125	1000	0.13	977	977	1
0.001	150	1000	0.15	1688	1688	2
0.001	175	1000	0.18	2680	2680	3
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0.001	250	1000	0.25	7813	7813	8
0.001	275	1000	0.28	10398	10398	10
0.001	300	1000	0.30	13500	13500	14
0.001	325	1000	0.33	17164	17164	17
0.001	350	1000	0.35	21438	21438	21
0.001	375	1000	0.38	26367	26367	26
0.001	400	1000	0.40	32000	32000	32
0.001	425	1000	0.43	38383	38383	38
0.001	450	1000	0.45	45563	45563	46
0.001	475	1000	0.48	53585	53585	54
0.001	500	1000	0.50	62500	62500	63
0.001	525	1000	0.53	72352	72352	72
0.001	550	1000	0.55	83188	83188	83
0.001	575	1000	0.58	95055	95055	95
0.001	600	1000	0.60	108000	108000	108
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GIVEN	RESULTING VALUE	
Output Power	Resulting Holdup Time	
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10	0.00	0.0
10	0.01	0.0
10	0.02	0.0
10	0.05	0.0
10	0.10	0.0
10	0.17	0.0
10	0.27	0.0
10	0.40	0.0
10	0.57	0.0
10	0.78	0.0
10	1.04	0.0
10	1.35	0.0
10	1.72	0.0
10	2.14	0.0
10	2.64	0.0
10	3.20	0.1
10	3.84	0.1
10	4.56	0.1
10	5.36	0.1
10	6.25	0.1
10	7.24	0.1
10	8.32	0.1
10	9.51	0.2
10	10.80	0.2
10	12.21	0.2

Very useful hold-up is achieved at 450V: 10 kW for 35 seconds

Continued on Page

Read and Understood By

Signed Date Signed Date

I would also appreciate you providing us with the inventors' full names, residence addresses, post office mailing addresses, counties in which they reside, and citizenships on the enclosed sheet and returning it to us so that we may prepare the formal papers. Please advise us if there is any question as to inventorship. Otherwise, we will assume that the named inventors on the attached sheet are correct.

If you have any questions regarding this matter, please do not hesitate to contact me.

With best regards,

Very truly yours,

Leah M. Reimer

Leah M. Reimer, Ph.D.

LMR:dkm
Enclosures

PROTON ENERGY SYSTEMS

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DATE: _____

Docket No.: PES-D-01 008

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Fuel Cell Backup Power Bridge Device Utilizing High Voltage Capacitor Energy Storage

PRIOR ART: (Related patents, dockets, reports, articles, texts, etc.)

none known

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See attached. This invention allows a backup power system, based on a fuel cell, to provide a temporary power "bridge" during the transition from normal power operation to backup power operation using a high voltage capacitor power source. This provides a simple replacement for a battery, super capacitor, or a flywheel bridge system. The novel solution is to use a high voltage (approx 500 VDC) low quality power supply to charge a medium size capacitor (10,000 uF (micro-Farads)) as an energy storage device and then discharge this into the existing high quality power supply system using another low quality / low cost regulator interface. The result is large energy storage with minimal component increase relative to other energy storage solutions.

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Disclosed Outside of Proton Energy Systems, Inc.? YES ☐ NO ☑

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Witness: _____ **Date:** _____ **Inventor:** _____

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PROTON ENERGY SYSTEMS

PROTON INVENTION DISCLOSURE QUESTIONNAIRE

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TITLE OF INVENTION:	
Fuel Cell Backup Power Bridge Device Utilizing High Voltage Capacitor Energy Storage	
DISCLOSURE NUMBER: PES-D-01 008	**LEGAL REFERENCE NUMBER:**

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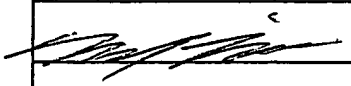
Inventor(s) Signature	Full Name	Proton Emp.	Phone #	Social Security No.
	Mark Lillis	yes	860 571-6533 x-236	021-46-2213

Title: Fuel Cell Bridge Capacitor System

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Continued on Page 14

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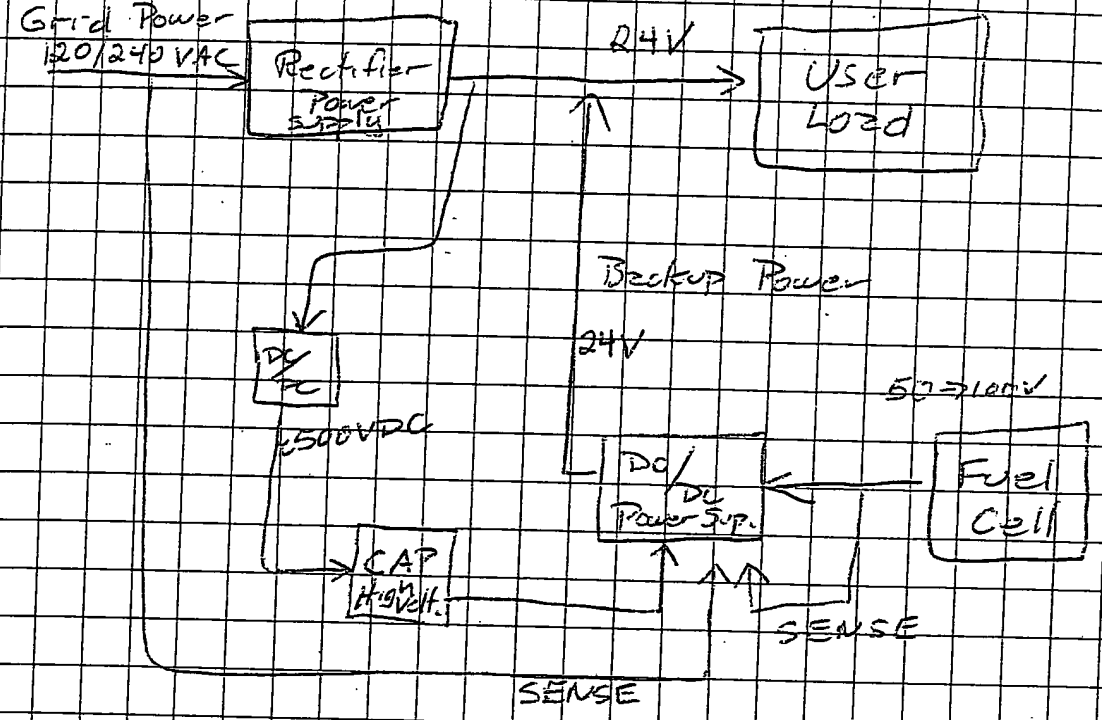
Typical Block Diagram



Typical Cap may be Mallory CGS772T450X8L
7700uF 450VDC/525 Surge

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GIVEN		RESULTING VALUES				
cap size	cap voltage	resulting cap	resulting charge	resulting energy	energy	energy
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0.0077	50	7700	0.39	481	481	0
0.0077	75	7700	0.58	1624	1622.5	2
0.0077	100	7700	0.77	3850	3850	4
0.0077	125	7700	0.96	7520	7520	8
0.0077	150	7700	1.16	12994	12994	13
0.0077	175	7700	1.35	20634	20634	21
0.0077	200	7700	1.54	30800	30800	31
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0.0077	250	7700	1.93	60156	60155	60
0.0077	275	7700	2.12	80068	80068	80
0.0077	300	7700	2.31	103950	103950	104
0.0077	325	7700	2.50	132163	132163	132
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0.0077	600	7700	4.62	831600	831600	832
0.0077	625	7700	4.81	939941	939941	940

GIVEN	RESULTING VALUE	
Output Power	Resulting Holdup Time	
kW	s	min
kilo-Watts	seconds	minutes
10	0.01	0.0
10	0.05	0.0
10	0.16	0.0
10	0.39	0.0
10	0.75	0.0
10	1.30	0.0
10	2.06	0.0
10	3.08	0.1
10	4.39	0.1
10	6.02	0.1
10	8.01	0.1
10	10.40	0.2
10	13.22	0.2
10	16.51	0.3
10	20.30	0.3
10	24.64	0.4
10	29.55	0.5
10	35.08	0.6
10	41.26	0.7
10	48.13	0.8
10	55.71	0.9
10	64.05	1.1
10	73.19	1.2
10	83.16	1.4
10	93.99	1.6

GIVEN		RESULTING VALUES				
cap size	cap voltage	resulting cap	resulting charge	resulting energy	energy	energy
F	V	uF	C	J	Ws	kWs
Farads	Volts	micro-Farads	Coulombs	Joules	Watt-seconds	kWatt-seconds
0.001	25	1000	0.03	8	8	0
0.001	50	1000	0.05	63	63	0
0.001	75	1000	0.08	211	211	0
0.001	100	1000	0.10	500	500	1
0.001	125	1000	0.13	977	977	1
0.001	150	1000	0.15	1688	1688	2
0.001	175	1000	0.18	2680	2680	3
0.001	200	1000	0.20	4000	4000	4
0.001	225	1000	0.23	5695	5695	6
0.001	250	1000	0.25	7813	7813	8
0.001	275	1000	0.28	10398	10398	10
0.001	300	1000	0.30	13500	13500	14
0.001	325	1000	0.33	17164	17164	17
0.001	350	1000	0.35	21438	21438	21
0.001	375	1000	0.38	26367	26367	26
0.001	400	1000	0.40	32000	32000	32
0.001	425	1000	0.43	38383	38383	38
0.001	450	1000	0.45	45563	45563	46
0.001	475	1000	0.48	53586	53586	54
0.001	500	1000	0.50	62500	62500	63
0.001	525	1000	0.53	72352	72352	72
0.001	550	1000	0.55	83188	83188	83
0.001	575	1000	0.58	95055	95055	95
0.001	600	1000	0.60	108000	108000	108
0.001	625	1000	0.63	122070	122070	122

GIVEN	RESULTING VALUE	
Output Power	Resulting Holdup Time	
kW	s	min
kilo-Watts	seconds	minutes
10	0.00	0.0
10	0.01	0.0
10	0.02	0.0
10	0.05	0.0
10	0.10	0.0
10	0.17	0.0
10	0.27	0.0
10	0.40	0.0
10	0.57	0.0
10	0.78	0.0
10	1.04	0.0
10	1.35	0.0
10	1.72	0.0
10	2.14	0.0
10	2.64	0.0
10	3.20	0.1
10	3.84	0.1
10	4.56	0.1
10	5.36	0.1
10	6.25	0.1
10	7.24	0.1
10	8.32	0.1
10	9.51	0.2
10	10.80	0.2
10	12.21	0.2

Very useful hold-up is achieved at 450V: 10 kW for 35 seconds

Continued on Page

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